REPORT

ON THE

CAWNPORE EXPERIMENTAL FARM OPERATIONS

DURING THE RABI SEASON, 1880-81.

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No. $\frac{1665A}{CCXXXIII}$ OF 1881.

FROM

THE OFFG. DIRECTOR, DEPT. OF AGRI. AND COMMERCE,
NORTH-WESTERN PROVINCES AND OUDH,

TO

THE SECRETARY TO GOVERNMENT,
NORTH-WESTERN PROVINCES AND OUDH.

DATED CAWNPORE, THE 21ST JULY, 1881.

SIR,

I HAVE the honor to submit the usual report on the Cawnpore Experimental Farm operations during the rabi season of 1880-81. As in previous reports, these operations are subdivided into (A) field experiments of a purely agricultural nature, and (B) the development and construction of improved agricultural implements.

(A.)—FIELD EXPERIMENTS.

2. During five months of the period under report I was absent on leave to Europe, but my departure and arrival were so timed that I was able to supervise the sowing of the rabi crops before I left, as well as their harvesting after my return. Unfortunately it was impossible for Mr. Harrison, who acted for me during my absence, to pay anything but occasional flying visits to the farm, since he was compelled to remain in camp throughout the cold season, and I think that some of the crops suffered in the way of imperfect irrigation from the want of strict supervision.

3. The season was in many respects a very peculiar one. As shown in my report for the preceding half-year, the rainfall of 1880 was abnormally light, amounting to 4·5 inches between June 1st and August 31st. A fall of 1·4 inches in September showed that Cawnpore caught the skirt of the cyclone which caused such deluges of rain in and near the hills ; but from September 18th to the end of the year the rainfall did not amount to three-tenths of an inch. The rabi crops are sown, as a rule, between October 15th and November 7th, during which period the ground was too dry to allow of germination if the seed was left to natural moisture. It was therefore necessary in every case to irrigate before sowing, and the crops were accordingly sown as well as raised by the help of canal-water. The following table shows the rainfall of the rabi under report :—

	Month.	*Rainfall in inches.*
1880	September	1 45
	October	0·05
	November	0·03
	December	0·2
1881	January	0·02
	February	0·21
	March	0·25
	April	0 00
	Total	2 21

There were therefore practically no winter rains, and this is the third year in which they have failed at Cawnpore.

4. Under these circumstances a really good harvest could scarcely have been expected. Seed sown in soil moistened by irrigation never germinates so regularly or so strongly as if sown in soil naturally moist, since it is extremely difficult to ensure that all portions of the field shall be irrigated alike, and surface irrigation in the deficiency of subsoil moisture cannot be expected to promote strong or healthy root growth. Hence the crops on the fields of good cultivators round the farm compared very badly with those of the rabi preceding, while the average production of wheat on the farm lands (calculated on 11 acres) only amounted to 15 maunds (=20 bushels) per acre, although the whole of the land was three times irrigated in addition to the irrigation necessary for ploughing and sowing. In certain cases, however, excellent outturns were obtained, amongst which I may mention 22½ maunds and 23 maunds per acre on fields manured respectively with a green crop and with poudrette.

5. The field experiments conducted during the season under report comprise experiments on—

(1) Different manures.
(2) Selection of seed.
(3) Irrigation.
(4) Deep cultivation.
(5) New staples—Cape oats from Australia and American maizes.
(6) Flax.

(1) Experiments on manures.

These may be thrown into two classes according as they were made—(*a*) with wheat or barley, (*b*) with sugarcane.

(*a*) *Experiments with wheat and barley.*

Mention was made in my two previous reports of a series of plots, each containing 400 square yards, which had been carefully marked out and set aside for the systematic trial of different manures. These plots are 50 in number and comprise two sets, one for the kharif and one for the rabi, each in duplicate, so as to give two parallel trials of each manure in each season. To prevent as far as possible all chance of mistakes, a label is attached to each plot with a description of its treatment, and the experiments, if carefully carried out, will furnish in time a valuable indication of the merits of the different manures which are available in the country, used singly and in combination. Reliable results cannot however be expected for the first two or three seasons until by similar cropping the plots have been reduced to a level and any differences in their previous treatment counteracted. This has as yet been done with only nine plots, which had been marked out and cultivated a year before the others. Their previous treatment, and details of their cultivation during the season under report, irrespective of the manures applied, are given below :—

Treatment on account of crop experimented with.				*Previous treatment.*		
Ploughing.	Seed and rate per acre.	Irrigation.	Weeding.	Year.	Manure.	Crop.
Twice (soil inverted) in October, 1880.	White wheat, 1½ maunds.	Three times from canal in addition to the watering for ploughing and sowing (*paleo*).	Once ...	1878-79 ... 1879-80 ... 1880 (kharif).	*Nil* ... *Nil* ... Same as now applied.	Barley. Cotton. Maize.

The following table shows the manures which were applied during the season under report, together with the results obtained :—

Manure and rate per acre.	Cost of manure per acre.	Outturn in lb. per acre.		*Cost of cultivation.	Value of produce.
		Grain.	Straw.		
	Rs. a. p			Rs. a. p	Rs. a. p.
1. Crop of indigo ploughed in during October ...	7 6 0	1,781·7	2,474·8	28 13 0	58 4 3
2. Cattle dung, 240 maunds	12 0 0	1,346·1	1,926·9	33 7 0	44 5 7
3. Cattle dung, 240 maunds (duplicate experiment to the above).	12 0 0	1,255·3	1,775·6	33 7 0	41 3 9
4. Cattle dung, 240 maunds, and gypsum, 240lb. ...	17 4 0	1,240 3	1,805·8	38 11 0	41 0 5
5. Ashes of 240 maunds dung	12 0 0	1,113 2	1,597 2	33 7 0	36 11 1
6. Poudrette, 240 maunds	12 0 0	1,884 6	2,704·3	33 7 0	62 1 11
7. Bone superphosphate, 225lb.	11 4 0	986·1	1,397·5	32 11 0	32 6 2
8. Bone-dust, 320lb.	4 0 0	795·5	1,228·1	25 7 0	26 11 7
9. *Nil*	...	707·8	1,291·7	21 7 0	24 13 6

Throwing these results into the form of a percentage on the outturn and the profit yielded by the unmanured plot, we obtain the following figures :—

	Increase per acre.		
	Per cent. in gross outturn.		Actual in net profit.
	Grain.	Straw.	
			Rs. a. p.
Manures yielding nitrogen—			
Green soiling	151	91	26 0 9
Poudrette	166	109	25 4 5
Cattle dung (average of two experiments), ...	83	47	6 0 2
Cattle dung plus gypsum	75	39	Decrease of Rs. 1-1-1.
Manures not yielding nitrogen—			
Ashes of cattle dung	56	23	Ditto „ 0-2-5.
Bone superphosphate	39	8	A net loss per acre.
		Decrease	
Bone dust	12	5	Decrease of Rs. 2 2-4.

The most prominent fact brought out by these figures is the great effect of manures containing nitrogen as compared with those which do not contain it. This appears to prove that it is in nitrogenous substances that the soil is most deficient; and since it is a well-known fact that manures only produce their full effect when in proper combination, it follows that, unless nitrogenous manure be added, the application of manures supplying phosphoric acid, potash, or lime can give but little profit. Hence superphosphate of lime in the experiments under notice only increased the outturn per acre by about 280lb. of grain and 100lb. of straw, which was not nearly sufficient to pay for its cost. The excellent results yielded by superphosphate in the *rabi* preceding the one now under report must have been due to the fields having previously had a good dressing of manure, which supplied the nitrogen requisite to draw out the full value of the superphosphate. No nitrogenous manure had, on the other hand, been supplied to the plot now under discussion for the past three years. I may note here that superphosphate unaccompanied by nitrogenous manure has been found to yield equally poor results by Mr. Lawes of Rothamsted, on whose farm the application of superphosphate alone (*though at the rate of* 14 *maunds to the acre*) continuously for 24 years was found only to have increased the outturn by an average of 2¼ maunds per acre.

* The head "cost of cultivation" includes the following items :—

	Rs. a. p.
Two ploughings	3 0 0
Clod-crushing	0 10 0
Seed	3 0 0
Sowing	1 11 0
Weeding	2 0 0
Total ...	10 5 0

	Rs. a. p.
Brought over ...	10 5 0
Irrigation—	
Canal dues	1 8 0
Lifting (for 3 waterings) ...	3 6 0
	4 14 0
Rent	6 4 0
Manure	Variable.
Total ...	21 7 0

6. Other points brought out by the foregoing table is the poverty of cattle dung, as used by the natives of this country, compared with either green soiling or poudrette; while the still smaller return given by the ashes of cattle dung effectually disproves the assertion which is sometimes made that the consumption of cattle dung as fuel occasions no real loss to the country so long as the ashes are utilized as manure. This may be true with freshly-cultivated soils which abound in nitrogen, but in the case of the long-cultivated fields of the Doab is absolutely incorrect.

7. The following explanations are necessary concerning the different manures, the effect of which has been discussed in the preceding paragraph.

Green soiling consisted in ploughing in a crop of indigo which had been grown on the plot during the preceding rains. The cost of such a crop is not estimated to exceed Rs. 7-6-0, since no rent can be charged to it, and there would be no need of irrigation in years of ordinary rainfall. The effect of a crop of the leguminous order in fixing nitrogen in the surface soil is well known, though opinions differ as to origin of this nitrogen: some authorities (of whom Ville is the chief) considering that it is actually fixed from the air, and hence is *added* to the soil; while others follow Lawes and Gilbert in asserting that it is merely derived from the subsoil, from which it is drawn up by the long roots of plants of this order. It may be mentioned that *san* hemp (*Crotalaria juncea*) is equally efficacious with indigo for the purpose of green soiling. A parallel experiment was made with hemp on a field belonging to a native cultivator, on one portion of which hemp was grown during the rains and ploughed in during September, while the other portion was left fallow. Wheat was sown in October on both portions, with the following results:—

	Area of plots in square yards.	Outturn.			
		Actual.		*Per acre.*	
		Grain.	Straw.	Grain.	Straw.
		℔.	℔.	℔.	℔.
Portion green soiled ...	200	45·5	80	1,101 1	1,936·0
,, left fallow ...	200	26·25	64·5	635 2	1,560·9

Here green soiling increased the outturn of grain by 73 per cent. and of straw by 24 per cent.

Cattle dung was of the same description as that ordinarily used by native cultivators, and is estimated to cost about Rs. 5 per 100 maunds.

Cattle dung and gypsum.—The addition of gypsum positively decreased the outturn. As to the use of gypsum as manure reference may be made to para. 8 following.

Bone superphosphate was estimated to cost Rs. 5 per 100℔. as shown below:—

	Rs. a. p.
66℔. bone-dust at 11 annas per maund	1 14 0
33℔. sulphuric acid at 2 annas per pound	0 2 0
Total ...	5 0 0

8. Other experiments in addition to those detailed above were made to test the manurial value of gypsum and human excreta.

Gypsum (sulphate of lime) has been found to be a valuable manure in some parts of England and America, not only as supplying lime to the soil, but also in virtue of the property which it possesses of fixing the volatile compounds of nitrogen, and so retaining them in the soil instead of allowing them to dissipate themselves in the air. At the suggestion of Mr. Buck I obtained a consignment of gypsum from the salt

range in the Panjab through the courtesy of Mr. Halsey, as well as from quarries in the neighbourhood of Naini Tál by the assistance of Mr. Lawder, C.E. Gypsum is at present rated absurdly high in the railway tariffs, being included amongst chemicals instead of amongst minerals. If however its use as manure was to become general, I have no doubt but that it would be reclassified, and in estimating its cost I have therefore assumed that it could be carried by rail at mineral rates. Under this assumption Naini Tál gypsum could be landed at Cawnpore for Rs. 1-12-0 per maund—

	Rs.	a	p	
Collection charges	0	8	0	per maund.
Carriage from Naini Tál to Bareilly	1	0	0	„
„ Bareilly to Cawnpore	0	4	0	„
Total ...	1	12	0	„

A large number of experiments were tried with gypsum during the season under report, but with the most discordant results. In one experiment (already noticed), in which it was associated with cattle dung, it actually decreased the outturn. The results of other experiments in which it was used by itself or with cattle dung in different proportions are given below :—

Number of experiment.	Area of plot in square yards.	Amount of gypsum per acre.	Outturn.			
			Actual.		*Per acre.*	
			Grain.	Straw.	Grain.	Straw.
		lb.	lb.	lb.	lb.	lb.
I.	400	360 ...	85·0	116·5	1,028·5	1,409·6
	400	*Nil* ...	58·5	106·75	707 8	1,291·6
II.	600	100 ...	217·78	·325 5	1,756 5	2,625 7
	600	200 ...	185 0	305·5	1,492·3	2,464 3
	106·7	*Nil* ...	40·25	72 25	1,825 7	3,277 3
III.	605	Gypsum 80 ...	105·0	149 0	840	1,192
	605	Dung, 216 mds. ...				
		No gypsum ...	155 0	227 0	1,240	1,816
		Dung, 216 mds. ...				

In experiment No. I. the use of 360lb. of gypsum increased the outturn of grain by 45 per cent. ; in experiment No. II. gypsum largely decreased the outturn, the decrease being larger with the larger amount of gypsum used ; the result of experiment No. III., in which gypsum was associated with cattle dung, agrees with that of the experiment noted in para. 7, the outturn being considerably decreased.

The experiments will be continued, but it is possible that the large amount of lime which the soil of the farm land contains, and which shows itself in the formation of numerous kankar-beds, may make the application of a further supply of lime in the shape of gypsum positively injurious.

Human excreta.—A trial was made of the system of movable latrines on trenches, which has been so often advocated for Indian villages. A piece of poor sandy land was trenched with the English plough, and a movable grass screen erected, which could be shifted along down the trench as occasion required. A boy was kept to shift the screen and to draw earth over the *excreta* morning and evening. The experiment could unfortunately be only continued for 80 days, during which time the screens were used by 11 persons daily. The plot of ground which was thus manured measured 311·6 square yards ; at this rate an acre would be manured in a year by the daily attendance of 37 persons. The plot of ground immediately adjoining the manured plot was taken as standard of comparison, being treated in

exactly the same manner as regards ploughing, sowing, and irrigation. Both plots were sown with barley and irrigated three times. The result is shown below:—

Area of plot in square yards.	Manured or unmanured.	Outturn.				Value of produce per acre.
		Actual.		Per acre.		
		Grain.	Straw.	Grain.	Straw.	
		lb.	lb.	lb.	lb.	Rs. a. p.
311·6	Manured ...	182·25	232	2,830·8	3,603 5	66 7 1
146·5	Unmanured ...	55·75	57·75	1,841·8	1,907 9	40 12 9

The excellent outturn given by the unmanured plot was doubtless owing to its having been ploughed up at the same time as the manured plot was trenched, and thus lay in open fallow from May until sowing time. But the produce of the manured plot was by far the best and amounted to 35 maunds to the acre, an astonishing crop from such poor land as that experimented with.

(*b*) *Manure experiments on sugarcane.*

9. The effect of cattle dung, guano, and bone superphosphate, each in two different proportions, was tried on about four acres of sugarcane. For the purpose of measuring the outturn rectangular plots, representing an average portion of the crop, were marked out in each field, and coarse undrained sugar (*gurh*) was manufactured from the cane produced by them. The method of cultivation, irrespective of manure, is shown in the following tabular form :—

Treatment on account of the crop experimented with.			*Previous treatment.*		
Ploughing.	Irrigation.	Grubbing and weeding.	Year.	Manure.	Crop.
Twice in February, 1880, before crop was sown.	Dung plots six times; guano and superphosphate plots five times.	Dung and guano plots grubbed and weeded four times; superphosphate plots three times. All plots covered with leaves in April, 1880.	1879-80 ...	Guano ...	Maize.

There was therefore a slight difference in irrigation and grubbing, the dung plots getting rather more water than the others and the superphosphate plots being only grubbed three times instead of four.

The variety of cane used on all the plots was that known as *matna*.

The results are shown below :—

Manure.		Area of plot in square yards.	Outturn.			Cost of cultivation per acre.	Value of outturn per acre.
			Actual.		Per acre.		
Kind.	Rate per acre.		Canes.	Sugar	Sugar.		
	Mds. s		lb.	lb.	lb.	Rs. a. p.	Rs. a. p.
Cattle dung ...	260 0	388·4	2,940	217·5	2 710·3	53 11 4	152 7 0
	260 0	135	384·5	34	1,218·9	53 11 4	68 8 2
		Average of the two above plots.			1,964·6	53 11 4	110 7 7
	130 0	315 3	1,194	1,005	1,542·7	47 3 4	86 11 9
Guano ...	12 35	244·4	1,335·25	105·5	2,089·2	166 11 4	117 8 1
	12 35	210	1,550 5	131	3,019 2	166 11 4	169 13 1
		Average of the two above plots.			2,554 2	166 11 4	143 10 7
	3 18	194·4	821	74 25	1,848·6	93 2 4	103 15 2
Bone superphosphate...	6 24	150	816·25	80·75	2,605 5	51 0 10	146 8 6
	6 24	144	757·25	76 25	2,562·8	51 0 10	144 1 9
		Average of the two above plots.			2,584·1	51 0 10	145 5 1
	3 32	113·3	388·5	37·25	1,591·3	44 10 10	89 7 10

The profits per acre yielded by each manure were therefore—

		Mds. s.	Rs. a. p.	
Dung	...	260 0	56 10 3	In calculating these profits cost of sugar manufacture has not been allowed for : this amounted to Re. 1-5-4 per maund of sugar.
Do.	...	130 0	39 8 5	
Guano	...	12 35	(loss of 23 0 9)	
Do.	...	3 18	10 12 10	
Bone superphosphate	...	6 25	94 4 3	
Ditto	...	3 32	44 11 0	

The heavy yield which resulted from superphosphate is explained by the nitrogenous manure which was applied in the form of guano, 12 months previously, and which allowed the phosphoric acid to exert its full power.

(2) Selection of seed.

10. The effect of this in the case of wheat was tried in two parallel experiments. The wheat-seed used was procured in the Cawnpore bazaar and was of very inferior quality. Selection was effected by the use of a grain-separator, which eliminated 25 per cent. of the smaller and more shrivelled grains. Two quarter-acre plots were marked off and each divided into two portions, on one of which seed selected as above was sown, and on the other unselected seed. The same amount of seed was sown in both cases. Each plot was irrigated three times. The results are given in the following table :—

Number of experiment.	Seed.	*Outturn per acre.*	
		Grain.	Straw.
		lb.	lb.
I. ...	Selected	1,046·0	1,486·0
	Unselected	814·0	1,492·0
II. ...	Selected	1,060·0	1,434·0
	Unselected	1,020·0	1,574·0

Selection of seed therefore increased the outturn of grain by 29 per cent. in one case and 4 per cent. in the other. The outturn on all four plots was very poor, and had it been larger, the advantage resulting from selection of seed would doubtless have been more conspicuous.

(3) Irrigation.

11. The effect of different numbers of waterings with canal water was tried on a series of five plots which were irrigated respectively 4, 3, 2, 1, and 0 times. Each plot measured 400 square yards and was ploughed twice before sowing, in August and October. The crop was cut on April 7th; the results were as follows :—

Number of waterings with dates.	*Outturn per acre.*		*Increase in outturn resulting from irrigation.*				Money value of the increase in produce due to irrigation, which cost at most Rs. 4-14 0 per acre, including canal dues.
	Grain.	Straw.	*Grain.*		*Straw.*		
			Per acre in lb.	Per cent	Per acre in lb.	Per cent.	
Four times.	lb.	lb.					Rs. a. p.
Novr. 26th, Jany. 2nd, Feby 4th, March 11th ...	1,603·2	2,910·0	1,352·2	538	2,268·7	353	46 4 6
Three times.							
Novr 29th, Jany. 8th, Feby., 21st	1,016·4	1,911·8	765 4	304	1,270·5	198	26 2 9
Twice.							
Decr. 26th, Feby. 6th ...	1,200 9	1,660·6	949·9	378	1,019·3	158	29 6 3
Once.							
January 4th	1,055 7	1,488·3	804·7	321	847 0	182	24 13 0
Not irrigated ...	251·0	641·3	...	...	...	...	...

The money value of the increase due to irrigation is even more disproportionate to the cost of the irrigation than in the case of similar experiments conducted on the farm during the rabi season of the preceding year: and with regard to the present experiments, it must be remembered that the first watering (*paleo*) on which the plots were ploughed and sown has not been taken into consideration, and that had not canal irrigation been available for this, no crop whatever could have been gathered.

It is noticeable how vastly a watering in March increased the outturn; when this was not given, the difference resulting from the plots having been watered once, twice, or three times is comparatively small.

12. In connection with the subject of irrigation I may mention the extraordinary difference which exhibited itself between the outturn of wheat-fields (*a*) ploughed up in July, so as to catch in open fallow what little rain fell, and (*b*) not ploughed up till September. This was especially noticeable in the case of one field which had been originally intended for cotton, and a portion of which had been ploughed up at the commencement of the rains, while the remainder was left unploughed till September, when the whole field was ploughed up and sown with wheat. The strip which had been first ploughed was accurately marked by a broad band of wheat running down the field, almost twice as tall and as thick as on the later-ploughed portions. Two typical plots were marked out in both portions and the crop carefully weighed. The result was:—

	Outturn per acre.		Value of crop per acre.
	Grain.	Straw.	
	lb.	lb.	Rs. a. p.
Portion ploughed in July	1,630·7	2,676·4	55 9 10
„ not ploughed till September	983·4	1,493·8	32 13 10

Hence the difference in value of outturn made by early ploughing amounted to over Rs. 22 per acre.

(4) Deep cultivation.

13. All the fields on the farm were cultivated with the soil-turning plough as in previous years, but only one experiment was made to test the results of this cultivation as compared with the native system, and this unfortunately was a complete failure. The plots on which the experiment was made were the same as those on which sorgho had been grown experimentally during the rains preceding, and their soil appears to have been exhausted, since the outturn of wheat was extremely small. Only six weeks intervened between the final cutting of sorgho and the sowing of the wheat, and this was too short a period to allow of the soil recovering itself. The outturns were so small as to be valueless.

Mention may be made, however, of a crop of castor which had been sown in the July preceding on some sandy land sloping down towards the Ganges ravines. Owing to the deep cultivation which the land had received the crop survived the failure of rains, and was the only crop of any kind gathered from land of this description for miles round. The crop was gathered in April, having received no irrigation whatever since it was sown. The result is shown below:—

Area of field in square yards.	*Outturn in castor seed.*		Value of crop per acre.
	Actual.	Per acre.	
	lb	lb	Rs. a. p.
3,936·1	116·5	145·7	5 0 0

This outturn is of course extremely small, but suffices to show the utility of deep cultivation, without which there would have been no crop whatever.

(5) New staples.

14. The cultivation of two new staples was attempted—of Cape oats and of American maizes.

Cape oats.—Some seed had been obtained from Australia through the courtesy of Mr. C. G. Palmer, C.E., who wrote of it as being the most "profitable hay crop grown in South Australia on the better classes of soils, very free from disease and standing even the Australian droughts." The crop was a complete success: it was watered three times, and treated in every way like an ordinary *rabi* crop, but grew far higher and thicker than the oats ordinarily cultivated in this country. If grown for cattle fodder, it should yield two or three cuttings of green fodder during the cold season, when cattle food is scarcest, the stalks being cut down each time as soon as the ears show signs of appearing. This could not be tried with the crop experimented with, as it was necessary to grow it for seed. The yield in grain and straw was very heavy, the grain amounting to 2,299lb. per acre and the straw to 3,993lb.

American maizes.—In the report for the preceding *kharíf* it was noted that there appeared to be more chance of success in cultivating American large-grained maizes as a cold-weather than as a rain crop. During the *rabi* under report a trial was made of the following maizes:—

American large white corn.	American Canada corn.
Ditto white flint corn.	Country maize from Jaunpur.

The seed of all these American maizes was acclimatized, not imported, having been produced in India from imported seed. Seed of the first-named variety had been raised in the Khatmandu valley, whence a small quantity was kindly sent for trial by Mr. C. E. Girdlestone, the Resident. The seed of the second and third American varieties had been raised on the Awa estate during the rains preceding, and hence had probably rather deteriorated in quality. But the results prove sufficiently well that some varieties of American maizes can be introduced into India as a cold-weather crop with great advantage, since if sown in September they will yield a large stock of food in February, at the time when the poorer classes are hardest pressed. The results are shown below, the first table giving details of cultivation and the second details of outturn:—

Treatment on account of crop experimented with.				*Previous treatment.*		
Ploughing.	Manure and rate per acre.	Irrigation.	Weeding.	Year.	Manure.	Crop.
Once in October	*Nil* ...	7 times from canal. American maize from Nepal 8 times.	Twice weeded,	1879-80 ... 1880-81 ... Kharíf ...	Dung ... *Nil* ...	Potatos. *Nil* ...

Area of plots in square yards.	Variety of maize.	Outturn.		Cost of cultivation.	Value of produce.
		Actual.	*Per acre.*		
		Hulled corn.	Hulled corn.		
		lb.	lb	Rs. a. p.	Rs. a. p.
222·2 ...	Large white corn from Nepal.	62·5	1,361·4	18 4 0	20 3 2
272·3 ...	American white flint	140·0	2,488·4	17 2 0	36 14 10
264·8 ...	American Canada corn.	237·0	4,348·2	17 2 0	64 8 7
318·75 ...	Country maize from Jaunpur.	146·5	2,224 5	17 2 0	33 0 2

The American variety known as Canada corn gave therefore a most enormous outturn and can be confidently recommended for cultivation.

15. **(6) Flax cultivation.**

A large consignment of Dutch flax seed was imported from England, but altogether failed to germinate. Recourse was therefore necessary to what acclimatized seed was in stock, and since the crop from which this had been produced in the year preceding was not a very healthy one, it is probable that its quality was far from being first rate.

Details of the method of cultivation are given below :—

Treatment on account of crop experimented with.						*Previous treatment.*			Cost of cultivation.
Area of plot in square yards.	Ploughing.	Manure and rate per acre.	Seed.	Irrigation.	Weeding	Year.	Manure.	Crop.	
									Rs. a. p.
3,122 4	Twice—once during rains and once in October; also country ploughed before sowing.	Dung, 135 maunds.	Acclimatized flax.	4 times from canal.	Once	1878-79, 1879-80 1880-81, (Kharif),	*Nil* .. Dung, 50 maunds. *Nil* ...	Wheat, Wheat, *Nil.*	29 13 0

The crop was an unequal one ; in some portions of the field it was excellent, but in other portions much dwarfed, apparently from lack of moisture. The seed was sown after an irrigation from the canal and not on natural moisture, and the irregular germination was, I think, due to unequal distribution of water. The field being on a slight slope, it was very difficult to distribute irrigation water evenly over the surface. In every way the season was against flax cultivation, which requires a damper air than Cawnpore affords, even in a cold weather season when the winter rains do not fail.

The flax was pulled, rippled (*i.e.*, the seed heads stripped off), and retted in exactly the same manner as was done in the preceding rabi. The stalks were broken in a machine invented by Dr. Collyer, which when worked by four coolies can break 200lbs. of flax daily. Scutching was performed by the farm apprentices and by coolie women, the amount scutched per head per day being about 1·6lb. of flax and 8lbs. of fine tow, which required no further scutching.

The return per acre was—

	lb.		£ s. d.
Flax, first quality ...	76	worth in England about ...	1 14 0
„ second „ ...	43	ditto ...	0 9 0
Tow, fine ...	60½	ditto ...	0 9 0
„ coarse ...	41	ditto ...	0 1 0
	220½	Total ...	2 13 0

A sample of the flax was submitted to the opinion of experts through the Secretary, Agri.-Horticultural Society of Calcutta, and was pronounced to be of good quality and easily saleable in the European markets at good prices.

Little progress has been made, however, towards finally deciding the question whether the production of flax in districts like Cawnpore offers any hope of substantial profits. The cost of scutching was extremely high, reaching Rs. 70 per ton, and it will be necessary to adopt some other system for the purpose than that of single hand labour, unless its efficiency is very greatly increased by practice.

(B)—THE DEVELOPMENT AND CONSTRUCTION OF IMPROVED AGRICULTURAL IMPLEMENTS.

16. **Ploughs.**—The pattern of the Kaisar plough has been somewhat altered, a long beam, after the fashion of the native plough, having been substituted for the short

beam with which it was previously fitted. This change was not made till after much consideration, since it renders the plough more weighty and cumbrous, but experience has shown that it popularizes the plough and makes its form appear less strange to native eyes. The price remains the same, Rs. 6 apiece. During the half-year under report 86 ploughs were distributed, 8 of which were given away and the rest sold. Out of the 86, 44 were of the newly-adopted pattern.

17. **Pumps.**—The form of the chain waterlift has been finally decided upon, and 11 were sold during the half-year, 7 of which were for depths less than 15, and the remaining 4 for depths less than 20 feet. As has been stated in previous reports, it is only for depths less than 20 feet that the waterlift is conspicuously more effective than any one now in use in the country.

18. **Winnowers.**—Adwantage was taken of the last *rabi* harvest to test by continuous use the pattern of winnower now made in the Farm workshops. On the whole it did well, though some important modifications suggested themselves in course of work, and when carried out were found to have added considerably to the effectiveness of the implement. Careful comparison was made of the work of (*a*) the winnower imported from England (one of Dell's) at a cost of Rs. 200, (*b*) one of the winnowers made up in the workshops at a cost of Rs. 35, and (*c*) the native method of winnowing. Trials were made on two days—once when a strong gale was blowing from the west, and again when there was only a very light breeze. In the former case the native method of winnowing consisted in merely pouring out the mixed grain and chaff (*bhusa*) out of a basket held up in the air, when the wind blew the chaff on one side, allowing the grain to fall straight down. In the latter case the wind was not strong enough to effect the separation, and the method followed was to make an artificial breeze by waving a sheet backwards and forwards in front of the basket from which the grain and chaff is poured out. The results are given below in tabular form :—

Method of winnowing.	*Labour required.*		*Results actually obtained.*		*Time and cost of winnowing 100 maunds, as deduced from the results.*	
	Number.	Cost.	Amount of wheat winnowed.	Time taken in winnowing.	Time taken to winnow 100 maunds.	Cost of winnowing 100 maunds.
		Annas.	lb.	M.	H. M.	Annas.
			First experiment in a gale of wind.			
English winnower ...	4	6¼	561¼	80	18 58	15·4
Farm " ...	3	5¼	376	91	32 16	21·1
Native method ...	3	5¼	537½	113	28 33	18·7
			Second experiment in a calm.			
English winnower ...	4	6¼	448	70	20 50	16·9
Farm " ...	3	5¼	410	125	40 39	26·6
Native method ...	3	10¼	503	195	51 41	67·8

So long, therefore, as a high wind is blowing cultivators are able to winnow grain after their own fashion at a rate actually cheaper than if they used the farm winnower ; but in a calm matters are very different, and the native method is shown in this case to be extremely tedious and expensive. West winds are undoubtedly prevalent during the season when winnowing is in progress, but long periods of light east winds or no wind at all are far from uncommon, and indeed there was such a period during this last harvest. In cases like this the winnower now being distributed will be of great service.

During the half-year under report 22 winnowers were sold at a price of Rs. 30 apiece.

19. **Windmill.**—Mention may here be made of a windmill, of a pattern known as the "Kewanee," which was imported from America during last cold weather mainly at the suggestion of the Government of India. The price as given by an agent of the manufacturers who was then travelling in India was 54 dollars, but this was incorrect,

and it was necessary to pay the manufacturers 84 dollars, which was the real price of the machine, less customary discount. The whole cost of the windmill landed at Cawnpore was close upon Rs. 300.

After numerous trials with different kinds of pumps the machine was fixed on the edge of a tank and attached to a plunger pump with a cylinder 7 inches in diameter and a 4-inch stroke. It was employed to lift water from a depth of 12 feet and to irrigate an adjoining field. The following figures show the results of various experiments made to test its discharge :—

Character of wind, with approximate velocity per hour.	Number of experiment.	Depth to water.	Quantity of water lifted per hour.		*Useful work performed.*	
			Cubic feet.	lb.	In foot lb. per minute.	Horse power.
		Feet.				
Strong breeze between 8 and 9 miles	I.	14	125·1	7,806·24	1,821 4	·055
Fair breeze: 6 miles ...	II.	11	74	4,617·6	846·5	·025
Ditto ...	III.	11	76	4,742·4	869·4	·026
Ditto ...	IV.	14	64 36	4,016·06	937 08	·028
Ditto ...	V	14	60·4	3,768 96	979 42	·026
Light breeze: 5 miles ...	VI.	11·5	62 6	3,906·2	748·6	·022
Gentle breeze: 3 miles ...	VII.	11 5	14 6	911·0	174·6	·005

The experiments are not so satisfactory as could be wished, since it was only possible to make a rough guess as to the most important factor—the velocity of the wind.

It may be noted that the discharges obtained in experiments II. to V. are slightly less than those of a lever lift (*dhenkoli*) worked by two men.

The minimum velocity of wind necessary to work a windmill with any degree of effectiveness may be taken as 4 miles an hour. It has been shown in a note by Colonel Brownlow, published in one of the Professional Papers on Indian Engineering (No. 33, July, 1879) that the number of months in which the *average* velocity of wind exceeds 4 miles an hour in these provinces is comparatively small. Observations at the five principal stations in the North-Western Provinces taken for seven months (November, 1871, to November, 1874) show that the average wind velocity of each month exceeded 4 miles an hour—

At Roorkee for 2 months.
" Bareilly " 7 "
" Agra " 16 "
" Lucknow " 7 "
" Benares " 13 "

But this low average velocity is in great part due to the almost invariable dropping of the wind at night. Taken hour by hour there are many periods in each month during which the velocity reaches a comparatively high figure. The following figures are abstracted from a table appended by Mr. Blandford to the note above quoted, showing the mean velocity of the wind at Agra for eight months, November to June, *i.e.*, the months during which irrigation is chiefly needed :—

Month.	*Average number of hours per diem in which velocity per hour exceeded*				
	4 miles.	5 miles.	6 miles.	7 miles.	8 miles.
November	7	3	2	...	...
December	5	1	...	...	...
January	9	6	4	2	...
February	9	7	3	1	...
March	9	7	5	4	...
April	13	10	9	3	2
May	24	19	9	4	1
June	23	16	13	10	5
	99	71	45	24	8

Taking the total number of hours as 192, the number during which the wind was blowing with a certain velocity was—

Velocity per hour.	Number of hours for which this velocity was maintained
4 miles	99—71 = 28
5 "	71—45 = 26
6 "	45—24 = 21
7 "	24— 8 = 16
8 "	8 = 8

Experiments with the Kewanee windmill have shown that with the wind velocity at 6 miles per hour its efficiency (in HP.) was about ·026. Taking ·6 as the measure of the efficiency of the pump which was worked by the windmill, we obtain ·04 HP. as the amount of power actually exerted by the mill, which exactly agrees with the figure arrived at by Smeaton on theoretical grounds. Applying this figure (·026 HP.) to the above table, and modifying it for each case according to the square of the velocity, we obtain the following result:—(28 × ·011 + 26 × ·018 + 21 × ·026 + 16 × ·035 + 8 × ·046) ÷ 192 = ·0117 HP.

The efficiency of a *dhenkoli* worked by two men turn and turn about for 8 hours a day is about ·028 HP., and the average efficiency spread over the whole 24 hours will be ·009, or only slightly less than that of the windmill.

The cost of the windmill together with the pump was Rs. 360, so that its daily cost (on account of interest and wear and tear at 15 per cent.) distributed over the eight irrigating months of the year will be 3·5 annas. To this must be added 1·5 annas as the wages of a boy to look after it, and so the total daily cost will be 5 annas. This is more than the daily cost of a *dhenkoli.*

A small windmill, such as the one experimented with, appears therefore to offer no advantages over the modes of lifting water now known to the country, while it is constantly liable to damage from sudden storms of wind. The windmill experimented with was totally disabled by a dust-storm which swept across the country in May, and repairing it entailed a great deal of expense and trouble.

I have the honor to be,

SIR,

Your most obedient servant,

J. B. FULLER,

Offg. Director, Dept. of Agriculture and Commerce.

ORDERS OF GOVERNMENT.

No. 1323 of 1881.

From

The SECRETARY to GOVERNMENT,

N.-W. Provinces and Oudh,

To

The DIRECTOR of AGRICULTURE and COMMERCE,

N.-W. Provinces and Oudh.

Dated Naini Tal, the 22nd August, 1881.

Sir,

Revenue Department.

I am directed to acknowledge your letter No. 1665A., dated the 21st July last, in which you reported on the Cawnpore Experimental Farm Operations during the rabi season of 1880-81.

2. The report gives a very clear statement of the work and results of the half-year. The problems connected with the improvement of agricultural methods and appliances are being patiently and judiciously studied, and will, it is hoped, before long be satisfactorily solved.

3. A full account is given of the trial of the "Kewanee" windmill imported from America, and the conclusion seems to be that the machine is hardly adapted for general use in this part of India. In G. O. No. 1119, dated 1st July, 1880, you were asked to report to the Government of the Panjáb the results of the trials of this windmill; and I am to request that if you have not already done so, you will now send the report required.

I have the honor to be,

Sir,

Your most obedient servant,

C. ROBERTSON,

Secretary to Government,
N.-W. Provinces and Oudh.

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